THE FIRST HST UV SPECTROSCOPIC OBSERVATION OF CHIRON IN OUTBURST. Joel Wm. Parker and S. Alan Stern (Southwest Research Institute, Boulder, CO 80302, USA, joel@swri.edu), Michel C. Festou (Observatoire Midi-Pyrénées, Toulouse, France), Michael F. A'Hearn (University of Maryland, College Park, MD 20742, USA), David A. Weintraub (Vanderbilt University, Nashville, TN 37235, USA.

We present ultraviolet (UV) observations of Chiron during two epochs using the *Hubble Space Telescope / Faint Object Spectrograph* (HST/FOS). The first observations (1996 Jan 23–24 UT) were made 3 weeks before Chiron's perihelion, and include a series of seven spectra obtained over 3.9 hours. A single follow-up observation was made 3 months later (1996 Apr 13 UT). The most intriguing result of our observations is that Chiron's UV continuum flux in April was 60% higher than expected from the January flux (Figure 1). The source of this significant increase is unknown, but may be tantalizing evidence of: a highly unusual phase function; recoating of the surface from an unobserved outburst; or a cold, persistent, near-surface "fog" (small scale height atmosphere) that experienced a peculiar, unresolved outburst. We derive models in the analysis of these scenarios and discuss the validity of each.

Chiron also exhibited a color change possibly related to this outburst. Chiron was characteristically gray in the UV (2600–3300 Å) in January 1996, with an average geometric albedo of 0.076 ± 0.003 (assuming a radius of 90 km) and displayed no detectable UV color variations with rotational phase. However, in the April 1996 data, the average UV geometric albedo was 0.109 ± 0.007, and we detect evidence for a blue color (Figure 2) which may be connected to the observed flux increase.

Our data also allow us to estimate Chiron's period. Compared to the value determined by Marcialis & Buratti (1993, Icarus, 104, 234), a slight increase in Chiron's period to 5.917834 hr appears to produce an improved agreement between our data and lightcurves obtained at earlier epochs.

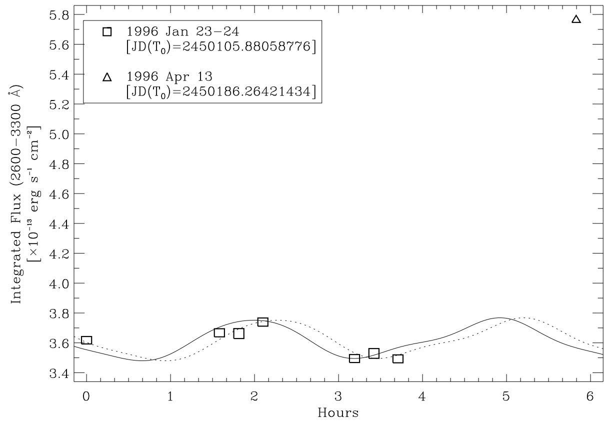

Figure 1: Chiron's UV lightcurve (integrated between 2600 Å and 3300 Å) from the HST/FOS spectra. This plot shows slightly more than one rotation period, which is about 5.9 hr and exhibits two maxima per period. The April value has been corrected to the heliocentric and geocentric distances of the January observations. The flux errors are the same size as the plotting symbols, i.e., the half-height of each symbol is equal to the 1σ error of the mean of the combined FOS errors. The solid line is the Fourier fit to the visible data from Bus et al. (1989, Icarus, 77, 223) and using a rotation period of 5.917813 hours (Marcialis & Buratti 1993, Icarus, 104, 234). The dotted line shows the shift if the period is increased by the 3σ value of 2.1×10^{-5} hours.

What We Saw

In Figure 1 we see clear evidence that the UV flux level of Chiron increased between the January and the April observations. The integrated 2600 Å to 3300 Å flux in the April spectrum is higher than that of the January spectrum by about 60%, indicating a significant increase in activity and/or albedo between the two epochs of observations. A comparison of Chiron's observed point-spread-functions (PSFs) and the FOS instrumental PSF shows that we do not detect a resolved, extended coma during either epoch.

Groundbased visible and IR data confirm our UV finding that Chiron experienced a significant flux increase between January and April. In the V and R passbands, Chiron brightened by about 0.4 mag between January 29 and March 27, then decreased about 0.1 mag by April 23 (Florczak et al. 1996, in International Conference on Asteroids, Comets, and Meteors, Versailles, 6). In the shortband K passband (2.16 μm), Chiron brightened by about 0.2 mag between February 9 and April 29 (H. Campins and J. Brownlee, private communication).

A similar flux difference is also seen in the acquisition images for both sets of our HST/FOS observations: both acquisition images were made with exactly identical instrumental setups, and the total number of distance-corrected counts in the April image, is higher than that of the January image by 23%. The wavelength range of the acquisition images is that of the detector: $\lambda \sim$ 1150–5400 Å. The fact that the flux difference in the acquisition image data is less than that in the UV spectra and is similar to that seen in the visible groundbased data is surprising if Chiron's flux change was uni-

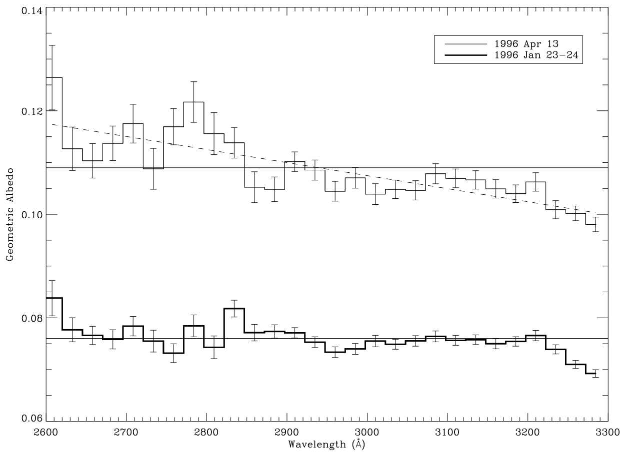

Figure 2: The geometric albedo for the January observations (lower, thick line) compared to the average albedo from the April observation (upper, thin line). The data have been binned into 25 Å bins. Values of 0.109 and 0.076 are shown by the horizontal lines, and the error bars show the error in the mean for each data bin. The dashed line shows a least-squares fit to the April data; the fit has a slope of -0.025 ± 0.005 per 1000 Å.

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formly gray, but it would make sense if there was a blue color slope so that the flux change was weaker at the longer wavelengths of the acquisition data.

In conjunction with the observed, 60% UV continuum flux increase, the April 1996 FOS spectrum reveals a 5σ detection of a blue continuum slope in the 2600–3300 Å bandpass of the FOS data (Figure 2). Further, we note that if one simply connects the available UV, visible, and IR data (see above), a progressively larger change in brightness is detected toward shorter wavelengths (Δmag = 0.2 in the IR, 0.3 in the visible, 0.5 in the UV). However, since the data taken at different wavelengths were not all contemporaneous, we cannot unambiguously confirm the validity of this color trend. But it is tempting to ascribe the coincidence of this apparent color change with the flux increase as the signature of small, possibly Rayleigh-scattering grains in Chiron's coma or on its surface associated with the higher albedo. However, the fact that Chiron was unresolved in the April measurements is strong evidence that if these effects are due to a coma, its spatial extent must be very compact.

What is the Cause of What We Saw?

What physical properties of Chiron may be responsible for this flux increase? We have identified three candidate explanations:

$\star$ *An unusual phase function?* $\star$

Because the April flux increase was so closely associated with Chiron's 1996 Arpil 1 opposition with Earth, it is possible that phase function effects are responsible. Although such a phase function and surge of a "typical asteroid" could account for most of the change in the visible magnitudes, it would account for only about one-third of the UV flux difference seen between January and April. Even the steepest UV phase function opposition surge derived by Roettger & Buratti (1994, Icarus, 112, 496) could account for no more than half of Chiron's observed UV flux increase. In any case, the phase function for an asteroid may not be appropriate for objects such as Chiron which show variations in activity throughout their orbits.

$\star$ *Recoating of the surface?* $\star$

It is possible that Chiron experienced a small, unobserved outburst that expelled matter which subsequently rained back onto Chiron's surface. However, any recoating event would have had to occur on a very short timescale, less than 3 months, and also not produce a coma detectable by the visible and IR groundbased observations made between January and April.

$\star$ *A peculiar, small scale height outburst?* $\star$

If Chiron experienced an outburst, then one would expect to see an extended coma, but as mentioned above, Chiron's observed PSFs are indistinguishable from the FOS instrumental PSF. We compare our data to models that use various nucleus/coma brightness ratios to show that there could have been a faint coma undetected by changes in the PSF, as long as such a coma didn't brighten to more than about 50% of the nuclear UV brightness in April. The spatial resolution of the FOS implies that any outburst must not have extended beyond about 1000 km above the surface.

None of these scenarios are without problems or unconfirmed assumptions in explaining Chiron's observed behavior. We will discuss our analysis and conclusions at the LPSC.